Grassland Bypass Project

Chapter 6
Project Impacts on the San Joaquin River
January 2008 – December 2009

Michael C. S. Eacock, U.S. Bureau of Reclamation[1]
Nigel W.T. Quinn, Lawrence Berkeley National Laboratory[2]

INTRODUCTION

The purpose of this chapter is to compare the loads of salt discharged by the Grassland Bypass Project with loads that might exist in the absence of the project. This comparison uses flow and salinity data for stations in the San Luis Drain, Mud Slough, Salt Slough, and the San Joaquin River from October 1985 to December 2009. Two methods are used:

- simple comparison of flow and salt loads as percentages, and
- theoretical dilution analysis.

The theoretical dilution analysis was agreed upon in meetings involving the US Bureau of Reclamation (Reclamation), the South Delta Water Agency and its legal counsel, and the California Regional Water Quality Control Board, as a means of demonstrating that the Project was not causing adverse downstream impacts. This analysis was not specified in the Compliance Monitoring Program (Reclamation et al., June 2002) or the Quality Assurance Project Plan (Reclamation et al., August 2002). Work continues to standardize the methodologies used to calculate loads and the theoretical dilution.

The 2001 Use Agreement[3] includes the following statement:

"It is the objective and intention of RECLAMATION and the AUTHORITY, among other things, to ensure that continued use of the Drain as provided in this Agreement results in improvement in water quality and environmental conditions in the San Joaquin River, delta, and estuary relative to the quality that existed prior to the term of this Agreement, insofar as such quality or conditions may be affected by drainage discharges from the Drainage Area (as hereinafter defined), and to ensure that such continued use of the Drain does not reduce the ability to meet the salinity standard at Vernalis compared to the ability to meet the salinity standard that existed prior to the term of this Agreement."

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[1] Natural Resource Specialist, US Bureau of Reclamation, South-Central California Area Office, 1243 N Street, Fresno, California 93721 (559) 487-5133 ceacock@mp.usbr.gov
[2] Staff Geological Scientist/Water Resources Engineer, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Building 70A-3317H, Berkeley, California 94720 (510) 486-7056 nquinn@lbl.gov
[3] U.S. Bureau of Reclamation and the San Luis and Delta-Mendota Water Authority, September 28, 2001. Agreement for Use of the San Luis Drain. Agreement No. 01-WC-20-2075.

COMPARISON OF FLOW AND SALT LOADS AS PERCENTAGES

Table 1a compares the monthly flows and loads of salt discharged by the Project (measured at Station B) with those in the San Joaquin River at Crows Landing (Station N) during 2008 and 2009. During the past two years, the Project contributed three to four percent of the monthly flows at Crows Landing, and fifteen to sixteen percent of the monthly salt load in the river. During the entire thirteen years of the Project, annual discharge from the Project was between one and five percent of the annual flow and up to 22 percent of the salt load in the river as measured at Crows Landing (Tables 1b and 1c).

Table 2 compares the volumes of water discharged from the 97,000 acre Grassland Drainage Area (GDA) with flows in the Grasslands watershed, as measured in Mud and Salt Sloughs. Prior to Water Year[4] 1997, the volume of water discharged from the GDA was twenty to thirty-two percent of the regional flow. The Project has reduced the GDA flow to nine to sixteen percent of the regional flow.

Table 3 compares the loads of salts discharged from the GDA with the salts in water in Mud and Salt Sloughs. Prior to WY 1997, the GDA discharged 41 to 59 percent of the regional salt load. The Grassland Bypass Project has been reduced the salt load to an average of 32 percent, ranging from 40 percent during WY 1997 (wet) and 21 percent during WY 2009 (below normal).

THEORETICAL DILUTION OF GBP DISCHARGES TO MEET VERNALIS STANDARDS

In order to assess the effect of Grassland Bypass Project (GBP) on salinity in the San Joaquin River, an analysis was developed to theoretically isolate the effects of GBP from other activities potentially affecting salinity concentrations in the river. Drainage from GBP was assumed as the only drainage relevant to project related changes in salt load on the San Joaquin River. The analysis was cast in terms of theoretical dilution water needed to bring the GBP discharges to the Vernalis seasonal salinity objectives.

The salinity objectives for Vernalis are 1,000 μS/cm[5] (640 mg/L[6] Total Dissolved Solids) in the winter months (September - March) and 700 μS/cm (448 mg/L TDS) in the summer months (April - August). Table 4 lists the theoretical volume of water that would be needed each year to dilute the combined salt loads from the GDA, measured at Station A, and the Grasslands Watershed, drained by Mud Slough and Salt Slough (Stations D & F), to meet the Vernalis standards. This analysis does not take into account any of the other operational criteria, nor does it consider salinity contributions to the River other than those derived from the GDA. The value of the analysis is that it permits a "with" and "without" project comparison with prior year hydrology, in terms (water quality releases from a reservoir) meaningful to water users and managers.

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4 Water Year = October 1 – September 30
[5] μS/cm = microSiemens per centimeter, equivalent to micromhos per centimeter
[6] mg/L = milligrams per liter, equivalent to parts per million

The assimilative capacity analysis considers the total volume of dilution water (assumed to have a salinity of 100 mg/L) that would be needed to reduce the drainage water alone to the salinity objective. Note that the monthly volume of dilution water is highly dependent on the 100 mg/L assumption. Note also that the relation between dilution water quality and required volume is non-linear.

Figure 1 shows the monthly theoretical dilution requirements for October 1985 through December 2009. Figure 2 shows the total theoretical dilution requirement for Water Year 1986 - 2009. The unshaded areas in Figures 1 and 2 represent the theoretical dilution requirements for salt loads generated by the Grasslands Watershed which includes the GDA and other agricultural areas, wetlands, and uncontrolled runoff from the Coast Range watersheds. The shaded area in both figures shows the theoretical dilution requirements for salt loads discharged from only the GDA.

The data for Figure 2 are summarized in Table 4. Prior to WY 1997, about 273,440 acre-feet would have been required to dilute the average annual volume of drainage water discharged from the GDA to meet the Vernalis standard. During the thirteen years of the Project, the theoretical annual volume of water needed to dilute the GDA drainage water was reduced 40 percent to less than 164,000 acre-feet. In comparison, the average annual volume of water needed to dilute the regional flows before WY 1997 was about 358,000 acre-feet, and about 301,000 during the Grassland Bypass Project through WY 2009; a reduction of only sixteen percent.

These percentages should be put into context of the 1987 – 1994 drought and the initiation of CVPIA water deliveries to wetlands (private, State and Federal) in the Grasslands Basin that preceded the authorization of the Grassland Bypass Project. The latter has profoundly affected the hydrology of the Grasslands Basin and has affected the timing of salt loading to the San Joaquin River.

Though WY 1999 through 2009 have been Dry to Above Normal, the theoretical volume of water needed to dilute the drainage water from the GDA was less than the theoretical volumes needed during the Dry and Critical drought years of 1987 – 1994 (Table 4, Figure 2). Note that the theoretical dilution for WY 2006, classified as a wet year, was less than that needed for WY 1992, a critical year.

Data for several more years will be necessary before the impact of the GBP on the San Joaquin River, as measured by dilution requirements for GDA discharges (Station A) and for the regional watershed, can be quantified with confidence. Preliminary results show a decreasing dilution requirement for discharges from the GDA since 1997, and an increasing requirement for the regional watershed.

CALCULATIONS

The formula for theoretical dilution is: $Q2 = Q1(C3-C1)/(C2-C3)$

Q1 =	Drainwater discharge in acre-feet per month	
Q2 =	Volume of water needed to dilute Q1 to meet Vernalis standards in acre-feet per month	
C1 =	Measured concentration of GBP drainage water in parts per million (mg/L)	
C2 =	Assumed concentration of dilution water	= 100 mg/L
C3 =	Vernalis standard concentration	= 448 mg/L April - August
		= 640 mg/L September - March

REFERENCES

U.S. Bureau of Reclamation and the San Luis & Delta-Mendota Water Authority. September 28, 2001. Agreement for Use of the San Luis Drain. Agreement No. 01-WC-20-2075.

U.S. Bureau of Reclamation, et al. June 2002. Monitoring Program for the Operation of the Grassland Bypass Project, Phase II October 1, 2001 – December 31, 2009.

U.S. Bureau of Reclamation, et al. August 22, 2002. Quality Assurance Project Plan for the Compliance Monitoring Program for the Use and Operation of the Grassland Bypass Project.

Table 1a. Comparison of Flows and Salt Loads Discharged to the San Joaquin River

	Monthly Flow			Monthly Salt Load		
	Grassland Bypass Project Station B acre-feet	San Joaquin River at Crows Landing Station N acre-feet	B as % of N	Grassland Bypass Project Station B tons	San Joaquin River at Crows Landing Station N tons	B as % of N
January 2008	1,660	86,440	2%	7,430	63,060	12%
February 2008	1,850	85,840	2%	8,300	65,930	13%
March 2008	1,780	63,070	3%	6,950	72,970	10%
April 2008	1,540	46,900	3%	6,720	59,730	11%
May 2008	1,790	67,080	3%	8,080	40,850	20%
June 2008	1,270	22,670	6%	5,670	26,820	21%
July 2008	980	18,300	5%	4,070	20,010	20%
August 2008	690	24,700	3%	2,850	20,290	14%
September 2008	690	20,480	3%	2,650	17,540	15%
October 2008	1,020	26,480	4%	3,580	20,010	18%
November 2008	1,270	30,940	4%	4,530	27,530	16%
December 2008	1,320	30,570	4%	5,370	32,600	16%
January 2009	1,270	30,610	4%	5,320	35,570	15%
February 2009	1,800	43,120	4%	7,610	47,080	16%
March 2009	1,780	51,450	3%	7,480	61,080	12%
April 2009	1,120	29,110	4%	5,290	39,330	13%
May 2009	770	29,690	3%	3,630	27,810	13%
June 2009	910	21,640	4%	4,170	22,860	18%
July 2009	650	14,710	4%	2,920	17,250	17%
August 2009	660	13,760	5%	2,920	15,180	19%
September 2009	590	14,590	4%	2,770	15,210	18%
October 2009	940	39,260	2%	3,610	29,130	12%
November 2009	1,150	34,530	3%	4,710	30,290	16%
December 2009	1,280	33,910	4%	5,850	38,120	15%

Data Sources: Station B - US Geological Survey Site 11262895

Station N - US Geological Survey Site 11274550

Table 1b. Comparison of Flows and Salt Loads Discharged to the San Joaquin River, Water Years 1997 - 2009

	Total Flow			Total Salt Load		
	Grassland Bypass Project Station B acre-feet	San Joaquin River at Crows Landing Station N acre-feet	B as % of N	Grassland Bypass Project Station B tons	San Joaquin River at Crows Landing Station N tons	B as % of N
WY 1997	37,560	3,844,610	1%	167,830	1,067,030	16%
WY 1998	45,950	4,904,910	1%	205,110	1,493,450	14%
WY 1999	32,310	1,015,480	3%	149,140	680,840	22%
WY 2000	31,260	1,027,440	3%	135,010	706,370	19%
WY 2001	28,250	653,430	4%	120,030	623,060	19%
WY 2002	28,400	533,960	5%	116,190	518,580	22%
WY 2003	27,270	546,130	5%	118,760	575,350	21%
WY 2004	27,700	554,550	5%	116,350	563,890	21%
WY 2005	30,160	1,721,000	2%	132,560	882,230	15%
WY 2006	25,970	3,437,650	1%	119,700	952,840	13%
WY 2007	18,540	606,360	3%	77,400	523,580	15%
WY 2008	15,670	586,030	3%	65,930	496,050	13%
WY 2009	13,160	336,670	4%	55,590	361,510	15%

Table 1c. Comparison of Flows and Salt Loads Discharged to the San Joaquin River, Calendar Years 1997 - 2009

	Total Flow			Total Salt Load		
	Grassland Bypass Project Station B acre-feet	San Joaquin River at Crows Landing Station N acre-feet	B as % of N	Grassland Bypass Project Station B tons	San Joaquin River at Crows Landing Station N tons	B as % of N
1997	37,490	3,590,680	1%	169,330	1,060,870	16%
1998	46,240	5,064,330	1%	208,860	1,497,060	14%
1999	32,250	864,600	4%	146,580	665,970	22%
2000	30,210	1,059,180	3%	128,600	692,060	19%
2001	28,010	638,210	4%	119,210	623,700	19%
2002	28,460	523,240	5%	117,760	528,650	22%
2003	27,550	521,480	5%	119,330	558,560	21%
2004	28,290	573,270	5%	118,000	575,090	21%
2005	29,610	1,755,440	2%	132,060	892,950	15%
2006	25,890	3,463,050	1%	116,890	952,470	12%
2007	17,990	550,850	3%	75,510	497,770	15%
2008	15,860	523,470	3%	66,200	467,340	14%
2009	12,920	356,380	4%	56,280	378,910	15%

Table 2. Annual Volume of Water Discharged from the Grassland Drainage Area and Mud/Salt Slough Watershed

Water Year (1)	Water Year Type	Water discharged from Grassland Drainage Area (2) acre-feet	Water discharged from Mud and Salt Sloughs (3) acre-feet	GDA discharge as percent of discharge from the Sloughs
WY 1986	Wet	67,010	284,320	24%
WY 1987	Critical	74,900	233,840	32%
WY 1988	Critical	65,330	230,450	28%
WY 1989	Critical	54,190	211,390	26%
WY 1990	Critical	41,660	194,660	21%
WY 1991	Critical	29,290	102,160	29%
WY 1992	Critical	24,530	85,430	29%
WY 1993	Wet	41,200	167,960	25%
WY 1994	Critical	38,670	183,550	21%
WY 1995	Wet	57,570	263,770	22%
WY 1996	Wet	52,980	267,950	20%
WY 1997	Wet	37,560	287,010	13%
WY 1998	Wet	45,950	378,670	12%
WY 1999	Above Normal	32,310	253,130	13%
WY 2000	Above Normal	31,260	235,490	13%
WY 2001	Dry	28,250	226,750	12%
WY 2002	Dry	28,400	180,160	16%
WY 2003	Below Normal	27,270	216,140	13%
WY 2004	Dry	27,700	210,520	13%
WY 2005	Wet	30,160	265,880	11%
WY 2006	Wet	25,970	284,900	9%
WY 2007	Critical	18,540	183,500	10%
WY 2008	Dry	15,670	152,610	10%
WY 2009	Below Normal	13,160	109,510	12%

Notes:

Pre-project data compiled by Nigel Quinn (LBNL) from CVRWQCB and USGS reports.

(1) Water Year - October 1 - September 30

(2) Grassland Drainage Area

GDA WY 1986 - 1996: CVRWQCB data

GDA WY 1997 - 2009: Station B - San Luis Drain, LBL, USGS, and SLDMWA data

(3) Mud and Salt Sloughs

Station D - Mud Slough near Gustine, US Geological Survey Site 11262900

Station F - Salt Slough at Hwy 165, US Geological Survey Site 11361100

Table 3. Annual Loads of Salt Discharged from the Grassland Drainage Area and Mud/Salt Slough Watershed

Water Year (1)	Water Year Type	Salt discharged from Grassland Drainage Area (2) tons	Salt discharged from Mud and Salt Sloughs (3) tons	GDA salt discharge as percent of discharge from the Sloughs
WY 1986	Wet	214,250	494,540	43%
WY 1987	Critical	241,526	438,900	55%
WY 1988	Critical	236,301	455,960	52%
WY 1989	Critical	202,420	389,330	52%
WY 1990	Critical	171,265	380,560	45%
WY 1991	Critical	129,899	221,540	59%
WY 1992	Critical	110,327	197,350	56%
WY 1993	Wet	183,021	336,520	54%
WY 1994	Critical	171,495	379,410	45%
WY 1995	Wet	237,530	499,340	48%
WY 1996	Wet	197,526	477,730	41%
WY 1997	Wet	176,700	446,690	40%
WY 1998	Wet	211,350	627,420	34%
WY 1999	Above Normal	143,880	401,340	36%
WY 2000	Above Normal	135,260	372,340	36%
WY 2001	Dry	125,100	382,900	33%
WY 2002	Dry	111,180	327,460	34%
WY 2003	Below Normal	113,610	374,000	30%
WY 2004	Dry	110,650	350,600	32%
WY 2005	Wet	127,030	436,320	29%
WY 2006	Wet	111,070	435,330	26%
WY 2007	Critical	77,140	276,370	28%
WY 2008	Dry	65,930	263,210	25%
WY 2009	Below Normal	55,590	260,400	21%

Notes:

Pre-project data compiled by Nigel Quinn (LBNL) from CVRWQCB and USGS reports.

(1) Water Year - October 1 - September 30

(2) Grassland Drainage Area

GDA WY 1986 - 1996: CVRWQCB data

GDA WY 1997 - 2009: Station A - San Luis Drain, LBL, USGS, and SLDMWA data

(3) Mud and Salt Sloughs

Station D - Mud Slough near Gustine, US Geological Survey Site 11262900

Station F - Salt Slough at Hwy 165, US Geological Survey Site 11361100

Table 4. Theoretical Annual Volumes of Dilution Water Needed to Meet Vernalis Standards

Water Year (1)	Water Year Type	Theoretical Annual Volume of Water Needed to Dilute GDA Discharge to Meet Vernalis Standard (2) acre-feet	Theoretical Annual Volume Water Needed to Dilute Regional Discharge to Meet Vernalis Standard (3) acre-feet
WY 1986	Wet	303,360	426,150
WY 1987	Critical	332,190	406,130
WY 1988	Critical	335,150	424,450
WY 1989	Critical	294,830	350,410
WY 1990	Critical	245,170	341,300
WY 1991	Critical	186,450	235,850
WY 1992	Critical	160,420	191,070
WY 1993	Wet	272,850	325,960
WY 1994	Critical	249,060	363,090
WY 1995	Wet	344,980	451,510
WY 1996	Wet	283,340	418,390
WY 1997	Wet	243,890	342,720
WY 1998	Wet	294,200	517,350
WY 1999	Above Normal	201,500	321,520
WY 2000	Above Normal	190,230	297,220
WY 2001	Dry	174,570	322,700
WY 2002	Dry	154,950	293,060
WY 2003	Below Normal	158,270	312,370
WY 2004	Dry	151,040	285,940
WY 2005	Wet	172,110	349,960
WY 2006	Wet	153,410	339,330
WY 2007	Critical	104,410	155,730
WY 2008	Dry	73,880	216,920
WY 2009	Below Normal	60,580	163,150

Notes:

Pre-project data compiled by Nigel Quinn (LBNL) from CVRWQCB and USGS reports.

(1) Water Year - October 1 - September 30

(2) Grassland Drainage Area

GDA WY 1986 - 1996: CVRWQCB data

GDA WY 1997 - 2009: Station A - San Luis Drain, LBL, USGS, and SLDMWA data

(3) Mud and Salt Sloughs

Station D - Mud Slough near Gustine, US Geological Survey Site 11262900

Station F - Salt Slough at Hwy 165, US Geological Survey Site 11361100

Figure 1. Theoretical Monthly Volumes of Water Needed to Dilute Drainage Water from the Grassland Drainage Area and Regional Watershed to Meet Vernalis Standards

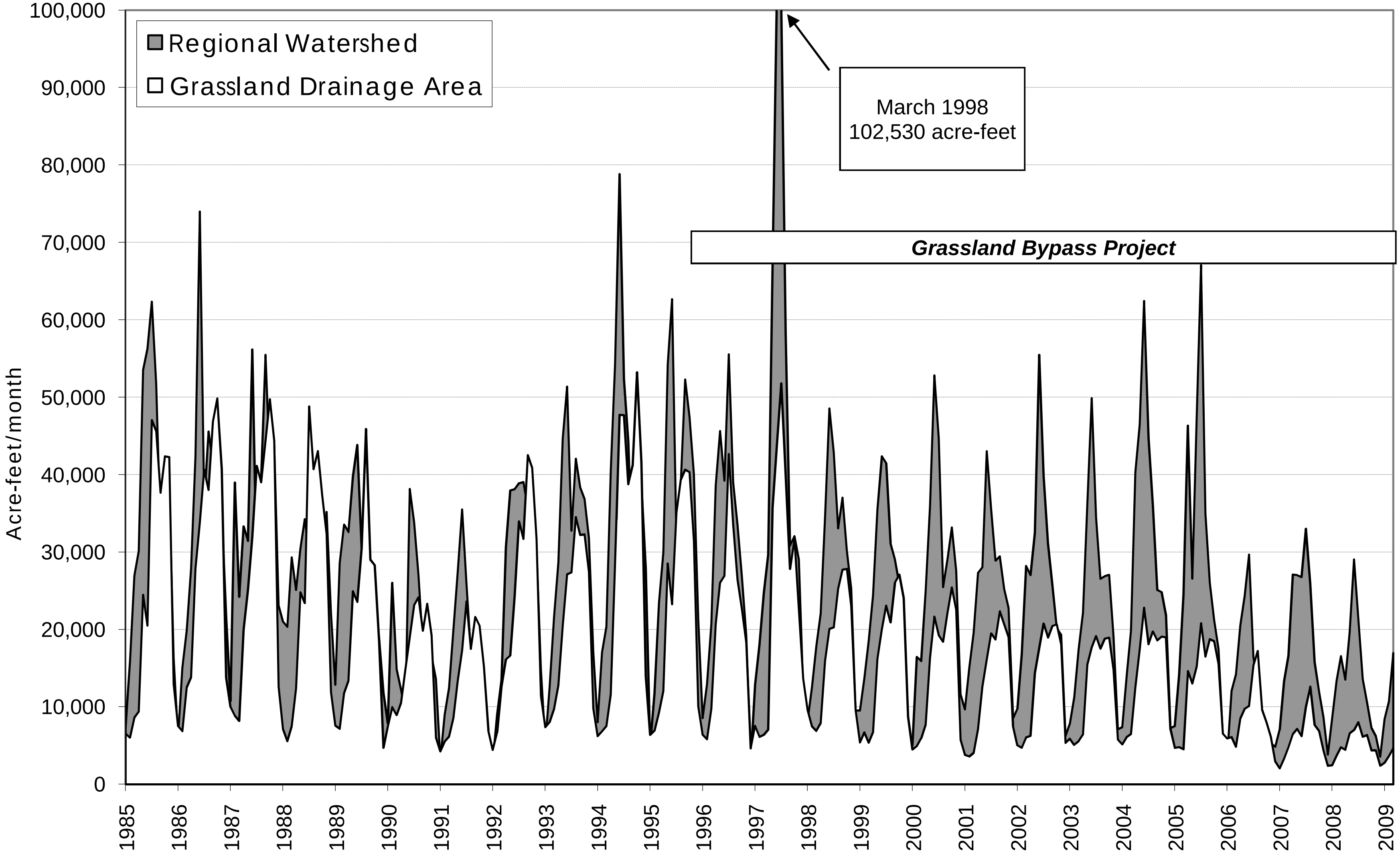

Figure 2 - Theoretical Annual Volumes of Water Needed to Dilute Drainage from the Grassland Drainage Area and the Regional Watershed to Meet Vernalis Standards